ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

*International Journal of Mechanical Engineering*

# Optimization and vibrational analysis of circular plate

Vadla Prashanth[1], Sarella Naresh Kumar [2], Dr. P. Srinivasarao[3]

[1] M-Tech, student, Department of Mechanical Engineering, Vardhaman College of engineering Shamshabad, Hyderabad

[2] Assistant Professor, Department of Mechanical Engineering,Vardhaman College of engineering Shamshabad, Hyderabad

[3] HOD Department of Mechanical Engineering, VardhamanCollege of engineering Shamshabad, Hyderabad

**Abstract**

Plate vibration is a special feature of the common mechanical vibration problem. The plate is a flat element with a thickness smaller than the lateral dimensions. ... Round plates are common in many structures such as nozzle cover, end-to-end compression vessels, pump diaphragms, turbine discs and bulkheads of submarines and aircraft.In this thesis the modeling tool created various round plates with the help of solid works and analyzed the results for each modeling model using Ansys workbench using different feature scales to improve dynamic stability using dynamic loading conditions. Different Materials (al-2048, Kevlar) Strong Behavior Comparison of effects with the effects of enhanced material (metal) and ultimately thesis optimal material with the appropriate aspect ratio.

**Tools were used:**

**Cad tool**: solid works

**Cae tool:** Ansys workbench

## 1. Introduction

### Vibration of plates

Plate vibration is a special case of the common mechanical vibration problem. The figures that control the movement of the plates are simpler than those of standard three-dimensional objects because the size of the plate is much smaller than the other two. This suggests that the theory of a two-dimensional plate would provide an excellent estimate of the actual three-dimensional motion of an object such as a plate, and that is found to be true.

### Literature review

Many researchers have studied long-term coil plate vibrations. The flexible features of angular plates are very important in many designs. Wook Kang et.al. [4] In their work, efforts are being made to find complete closed-ended form solutions with better accuracy than modal formations and existing natural waves. In tree discs such as a circular plate, the base and boundary conditions are much more difficult to achieve than those that are completely independent. Therefore, this study only works on completely free cases. It will assess the feasibility of detecting the expansive plates of both polar orthotropic and isotropic plates. The results of this study can be used in parametric studies to test for dynamic and non-destructive behavior during the initial design process.

Cheung Y. K. and Zhou D [6]., Using the Rayleigh-Ritz method, developed Timoshenko's solid metal works as a welcome works to analyze the free vibration of Mind-lin plates with the same elastic (translating / rotating) blocks.

U-Kanka Raju K, etc. [11] the effect of non-linear vibrations on the free rotation of intermediate rectangular plates was studied. The effect of geometric impurities on the flexible free vibration of rectangular plates has been moderately investigated in this paper. The construction of the finished element is used to obtain indirect periodic measurements in line on other rectangular plates. A relatively consistent rectangular feature, including the effects of shear deformation and rotating inertia, is developed and used for analysis. The results are presented in both supported and closed borders.

### Aim of the thesis

In this thesis different circular plates were developed with the help of modelling tool solid works, and analyzing with Ansys workbench by applying dynamic loading conditions, here circular plate dimensions were taken from research paper,

For design1, here outer diameter were consider as a = 110mm, and inner diameter value consider as b = 20mm and thickness value as consider t = 2mm. here aspect ratio were consider as b/a = 20/110 = 0.182, based on this here different aspect ratio values circular plates were developed,

Here design 2 were consider with a = 125mm, b = 25mm, b/a = 0.2

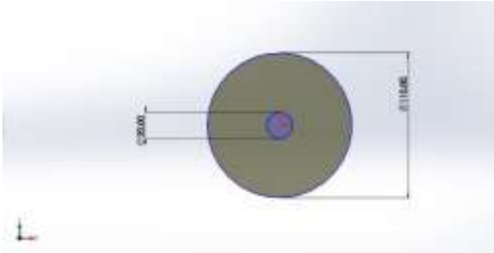
Here design 3 were consider with a = 120mm, b = 17.5mm, b/a = 0.146

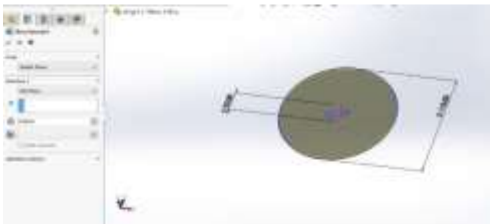
Here design 4 were consider with a = 110mm, b = 25mm, b/a = 0.227

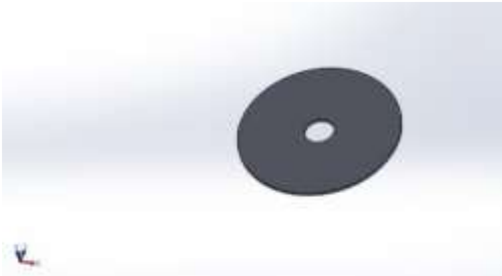
Here design 5 were consider with a = 110mm, b = 17.5mm, b/a = 0.159

And comparing results with each modelling, and also suggesting different materials (al-2048, Kevlar) dynamic behavior, comparing results with exiting material results (steel), finally thesis conclude with optimum aspect ratio with optimum material.

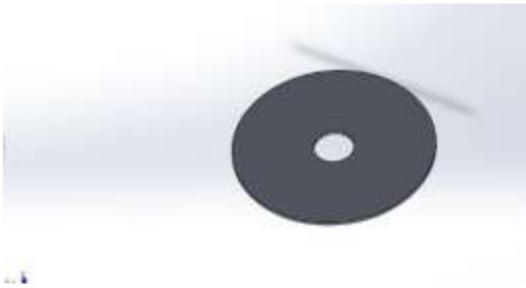
**Designing process**





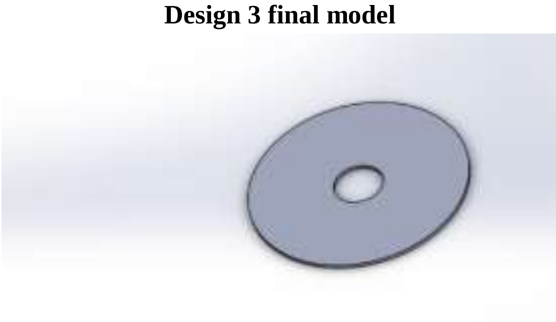


**Design1 final model**

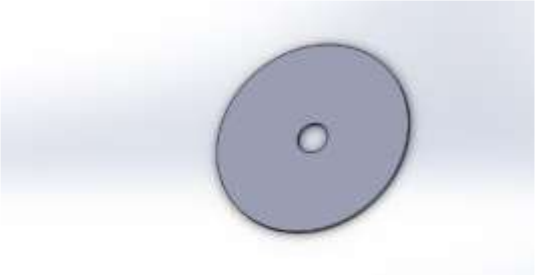


**Design2 final model**

**Design 3 final model**



**Design 4 final model**



**Design5 final model**

**Analysis results**

**Material properties**

**Steel**

Young's modulus: - 2.0*10^11 Pa Poison ratio: 0.29

Density: 7850 Kg/m^3

Yield strength: 250 Mpa

**Al-2048**

Young's modulus: - 70*10^9 Pa

Poison ratio: 0.33

Density: 2750 Kg/m^3

Yield strength: 415 Mpa

**Kevlar**

Young's modulus: - 83e9 Pa

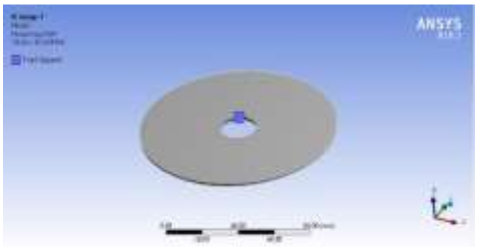
Poison ratio: 0.29

Density: 1440 Kg/m^3

Yield strength: 650 Mpa

**Meshing**

**Boundary conditions**

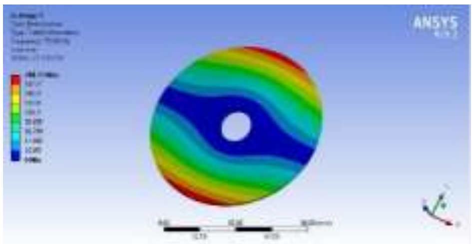


Select fixed support and select inner hole and enter no of modes 6 and then solve results

**Design1**

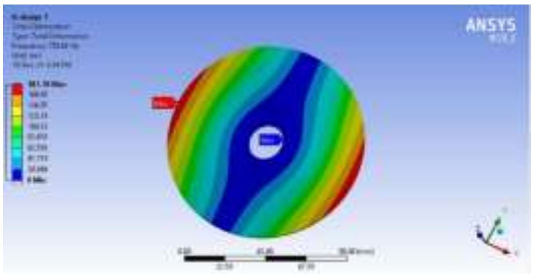
**Steel**

**Mode1**



Above image shows the natural frequency results of circular plate, and it consider as design1, this design1 is having “a” value 110mm and this value represent outer diameter of the object, and “b” value is 20mm, and this value is consider as inner diameter of the circle, here natural frequency values calculated for steel material and value is 735.85Hz for mode1

**Mode2**




Above image shows the natural frequency results of circular plate, and it consider as design1, this design1 is having “a” value 110mm and this value represent outer diameter of the object, and “b” value is 20mm, and this value is consider as inner diameter of the circle, here natural frequency values calculated for steel material and value is 738.62Hz for mode2

Above image shows the natural frequency results of circular plate, and it consider as design1, this design1 is having “a” value 110mm and this value represent outer diameter of the object, and “b” value is 20mm, and this value is consider as inner diameter of the circle, here natural frequency values calculated for steel material and value is 2007Hz for mode6

**Table**

| Design 1 | steel | Al-2048 | Kevlar |
|---|---|---|---|
| Mode 1 (Hz) | 735.85 | 746.26 | 1101.9 |
| Mode 2 (Hz) | 738.62 | 749.74 | 1105.8 |
| Mode 3 (Hz) | 806.37 | 821.32 | 1205.7 |
| Mode 4 (Hz) | 1003.4 | 1000 | 1511.1 |
| Mode 5 (Hz) | 1003.9 | 1000.5 | 1511.7 |
| Mode 6 (Hz) | 2007 | 1995.4 | 3024.4 |

| Design 2 | steel | Al-2048 | Kevlar |
|---|---|---|---|
| Mode 1 (Hz) | 604.19 | 612.94 | 904.68 |
| Mode 2 (Hz) | 606.55 | 615.93 | 907.98 |
| Mode 3 (Hz) | 651.33 | 663.67 | 973.79 |
| Mode 4 (Hz) | 803.29 | 801.32 | 1209.3 |
| Mode 5 (Hz) | 803.95 | 802.12 | 1210.3 |
| Mode 6 (Hz) | 1563 | 1554.2 | 2355.2 |

| Design 3 | steel | Al-2048 | Kevlar |
|---|---|---|---|
| Mode 1 (Hz) | 552.47 | 560.3 | 827.33 |
| Mode 2 (Hz) | 553.57 | 561.69 | 828.86 |
| Mode 3 (Hz) | 628.13 | 639.55 | 939.3 |
| Mode 4 (Hz) | 799.26 | 795.4 | 1204.1 |
| Mode 5 (Hz) | 799.64 | 795.84 | 1204.7 |
| Mode 6 (Hz) | 1678.2 | 1668.3 | 2529 |

| Design 4 | steel | Al-2048 | Kevlar |
|---|---|---|---|
| Mode 1 (Hz) | 850.5 | 863.65 | 1273.2 |
| Mode 2 (Hz) | 851.61 | 865.03 | 1274.7 |
| Mode 3 (Hz) | 898.14 | 915.68 | 1342.6 |
| Mode 4 (Hz) | 1091.9 | 1090.8 | 1643.2 |
| Mode 5 (Hz) | 1092.5 | 1091.6 | 1644 |
| Mode 6 (Hz) | 2034.8 | 2023.7 | 3065.9 |

| Design 5 | steel | Al-2048 | Kevlar |
|---|---|---|---|
| Mode 1 (Hz) | 685.91 | 695.68 | 1027.1 |
| Mode 2 (Hz) | 688.3 | 698.82 | 1030.4 |
| Mode 3 (Hz) | 768.82 | 783.11 | 1149.6 |
| Mode 4 (Hz) | 969.18 | 965.15 | 1459.9 |
| Mode 5 (Hz) | 969.32 | 965.29 | 1460.1 |
| Mode 6 (Hz) | 1999.2 | 1987.5 | 3012.7 |

**Applications of circular plates**

Circular plates are used in several machine components,

- such as circular saw blades,
- Disc brake plates,
- Diaphragm springs etc.

## CONCLUSION

In this thesis different circular plates were developed with the help of modelling tool solid works, and analyzing with Ansys workbench by applying dynamic loading conditions, here circular plate dimensions were taken from research paper, For design1, here outer diameter were consider as a = 110mm, and inner diameter value consider as b = 20mm and thickness value as consider t = 2mm. here aspect ratio were consider as b/a = 20/110 = 0.182, based on this here different aspect ratio values circular plates were developed,

Here design 2 were consider with a = 125mm, b = 25mm, b/a = 0.2
Here design 3 were consider with a = 120mm, b = 17.5mm, b/a = 0.146
Here design 4 were consider with a = 110mm, b = 25mm, b/a = 0.227
Here design 5 were consider with a = 110mm, b = 17.5mm, b/a = 0.159

From analysis results here observed that when outer diameter is constant for outer area, and changing “b” values, here observed that while increasing b/a value dynamic stability is increasing, among all design4 with aspect ratio 0.227 is having highest natural frequency range values.

In $2^{nd}$ case here inner diameter values were consider as constant, and changing outer diameter values. Here design 2 & design 4 values having same inner diameter values, among them design 4 is having better results, it means while decreasing outer diameter values dynamic behavior increasing.

From design 3 & design 5 results, same as high aspect ratio plates are having high dynamic stability values, in this case design 5 is having highest natural frequency values,

When considering only aspect ratio values, design 1, design 4, design 5, are having highest natural frequency value compare to design 2 and design 3, even though design 2 is having $2^{nd}$ highest aspect ratio values but it got least natural frequency values, so that it proves only aspect ratio values were not affect the dynamic behavior of circular plates, it is more important inner and outer diameter values, finally thesis conclude with Kevlar material with design 4 is having optimum results.

## REFERENCES


[1] A.W. Leissa, The Shock and Vibration Digest (Plate vibration research, 1981).

[2] L. Cheng, et.al. Vibration analysis of annular-like plates, *Journal of Sound and Vibration, vol. 262*, pp. (2003), 1153–1170.

[3] Weisensel G. N, Natural Frequency Information for Circular and Annular Plates, *Journal of Sound and Vibration,) vol. 133(l)*, (1989), 129-134.

[4] Wook Kang & et.al, Approximate closed form solutions for free vibration of polar orthotropic circular plates, *Journal of Applied Acoustics*, *vol. 66* (2005), 1162–1179.

[5] Z.H.Zhou et.al, Natural vibration of circular and annular thin plates by Hamiltonian approach, *Journal of Sound and Vibration*, vol.330, (2011), 1005–1017.

[6] Cheung Y. K., Zhou D. Vibrations of moderately thick rectangular plates in terms of a set of staticTimoshenko beam functions. Journal of Computers and Structures, Vol. 78, 2000, p. 757-768.

[7] Dawe D. J., Roufaeil O. L. Rayleigh-Ritz vibration analysis of Mindlin plates. Journal of Sound and Vibration, Vol. 69, Issue 3, 1980, p. 345-359.

[8] Eftekhari S. A., Jafari A. A. High accuracy mixed finite Element-Ritz formulation for free vibration analysis of plates with general boundary conditions. Applied Mathematics and Computation, Vol. 219, 2012, p. 1312-1344.

[9] Ferreira A. J. M. Free Vibration analysis of Timoshenko beams and Mindlin plates by radial basis functions. International Journal of Computational Methods, Vol. 2, Issue 1, 2005, p. 15-31.
[10] Han J. B., Liew K. M. Static analysis of Mindlin plates: the differential quadrature element method (DQEM). Journal of Computer Methods in Applied Mechanics and Engineering, Vol. 177, 1999, p. 51-75.
[11] Kanaka Raju K., et al. Effect of geometric non-linearity on the free flexural vibrations of moderately thick rectangular plates. Journal of Computers and Structures, Vol. 9, 1978, p. 441-444.
[12] Lee J. M., Kim K. C. Vibration analysis of rectangular isotropic plates using Mindlinplatecharacteristic functions. Journal of Sound and Vibration, Vol. 187, Issue 5, 1995, p. 865-877.